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Title: Generator Powered Plasma Focus

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Abstract

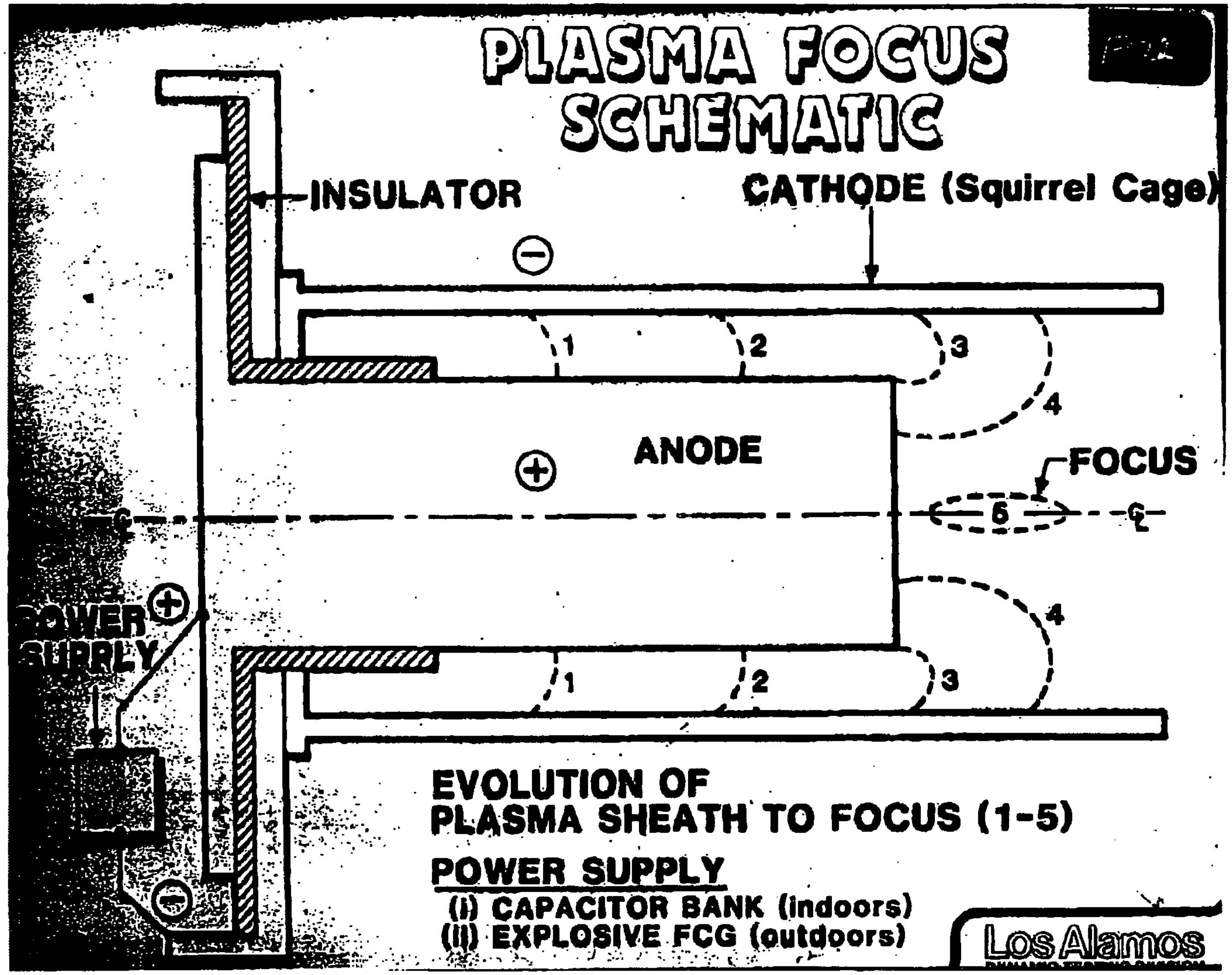
An earlier set of experiments will be described briefly, in which plate flux compression generators were used to power a Plasma Focus. Currents, voltages and "rundown times" obtained in these experiments are shown to agree well with a simple model. This same model is then used to show how dramatic operational improvements could be obtained with use of an appropriate fuse, provided the model remained valid.

Dense Plasma Focus Introduction

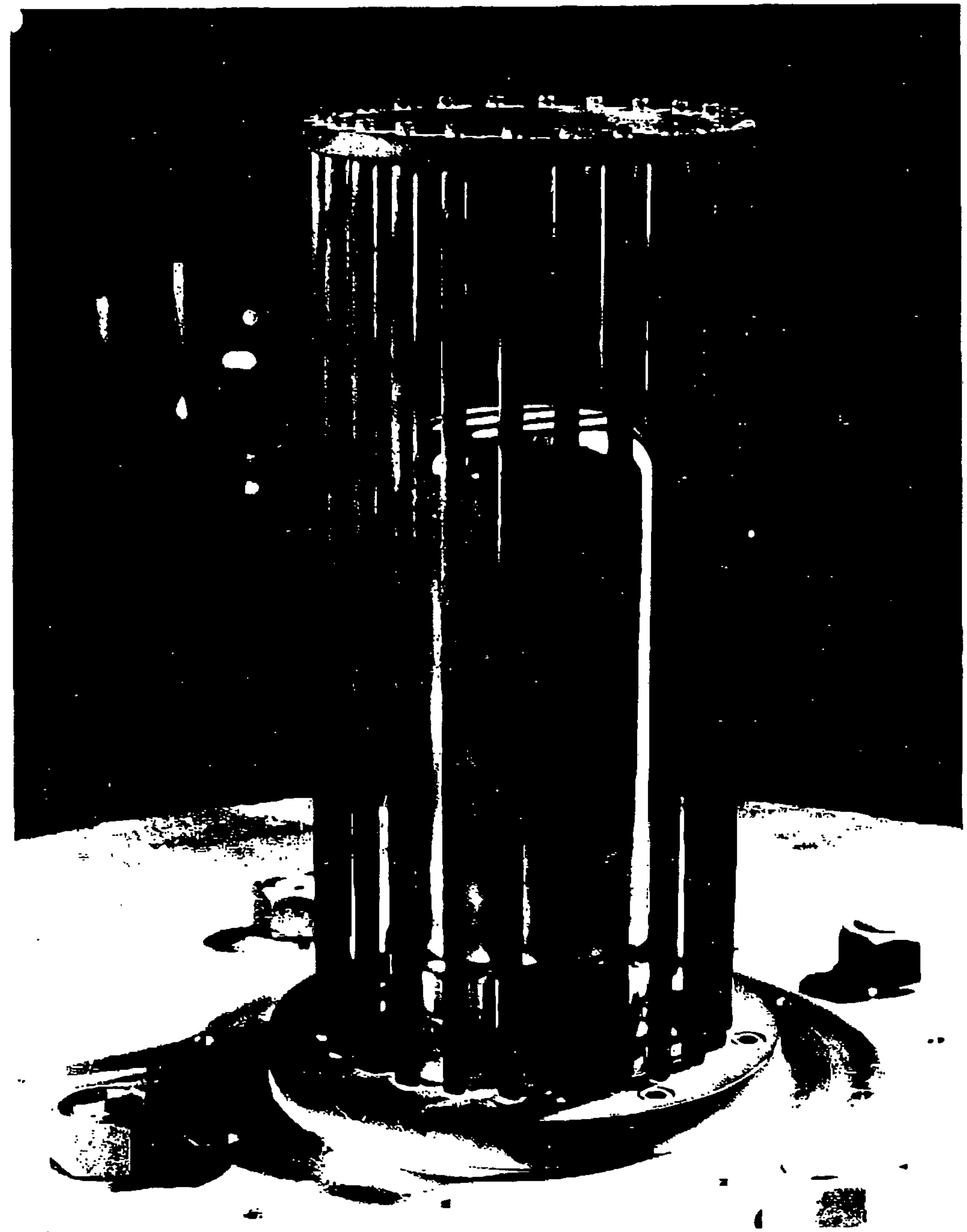
The Dense Plasma Focus, or DPF, is a relatively simple laboratory device consisting of a cathode and anode mounted in a chamber into which various gases may be introduced. A fast high voltage pulse is applied to the system that breaks down the gas and results in a subsequent concentration, or focus, of plasma formed from the gas. Depending upon the type of gas used and its initial pressure, the system can generate copious amounts of radiation or large numbers of neutrons when deuterium or deuterium-tritium mixes are used.

Capacitor banks are the normal energy sources for plasma focuses. The discussion below shows how a "plate" generator has been used to replace a large capacitor bank,

DPF Schematic, Showing Sheath Rundown and Focus Formation

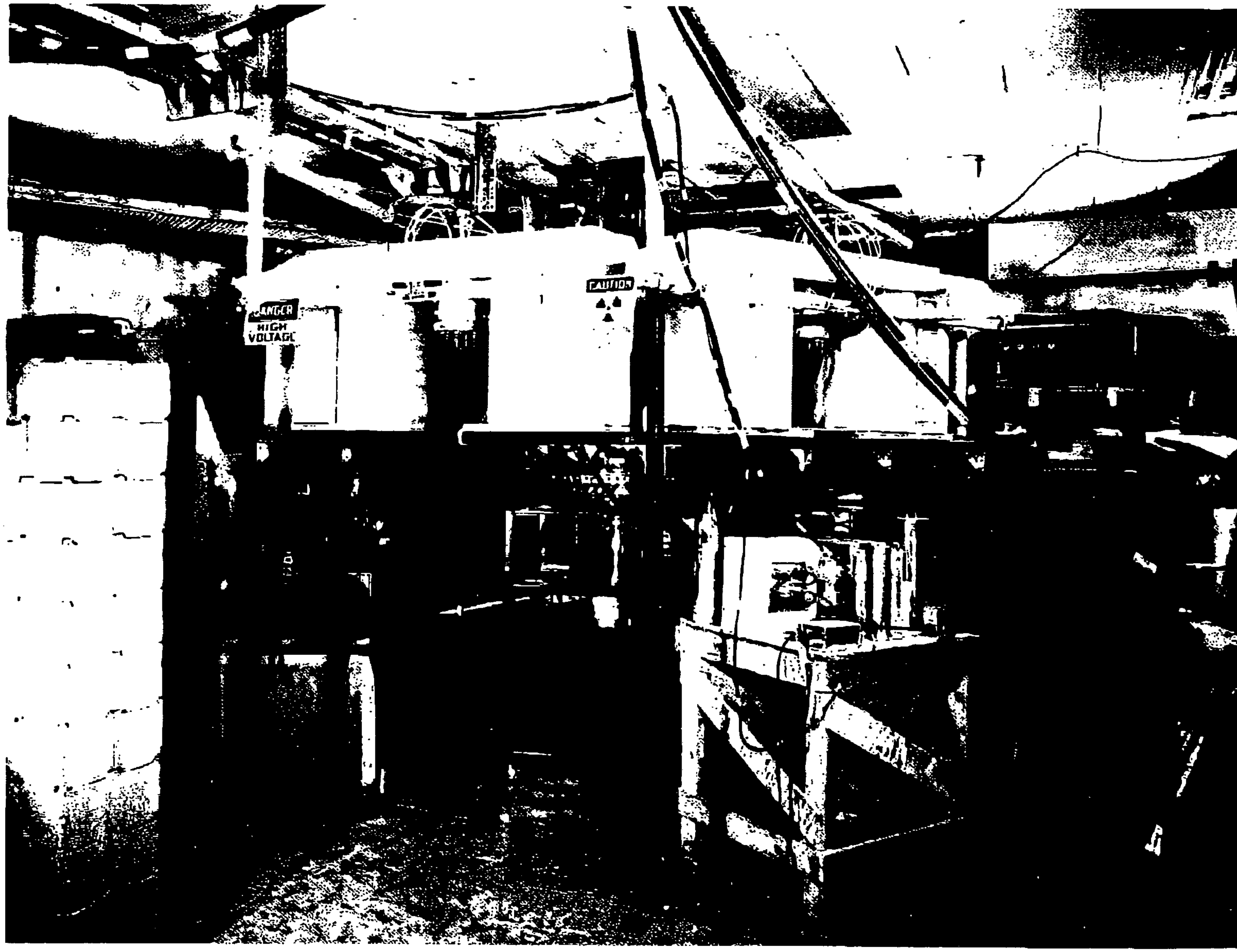


DPF: "Squirrel Cage" Cathode and Anode



DPF in Laboratory in Large Chamber. Two Smaller Chambers, as well as Extra Focus Assembly, are Also Shown

Indoor DPF, 20 kV, 72 kJ. Used to "Warm-up" Focus Which is Then Transported to Firing Site



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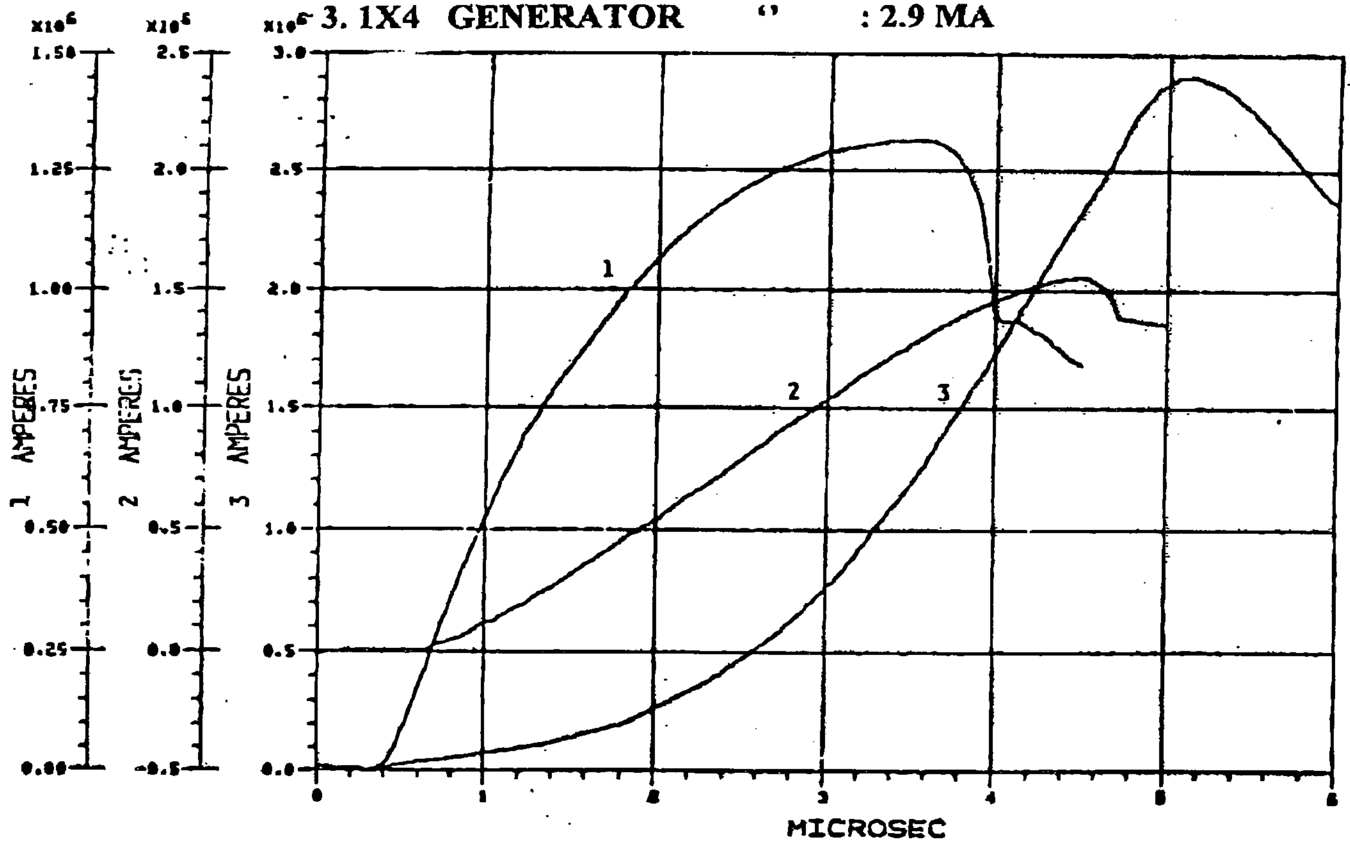
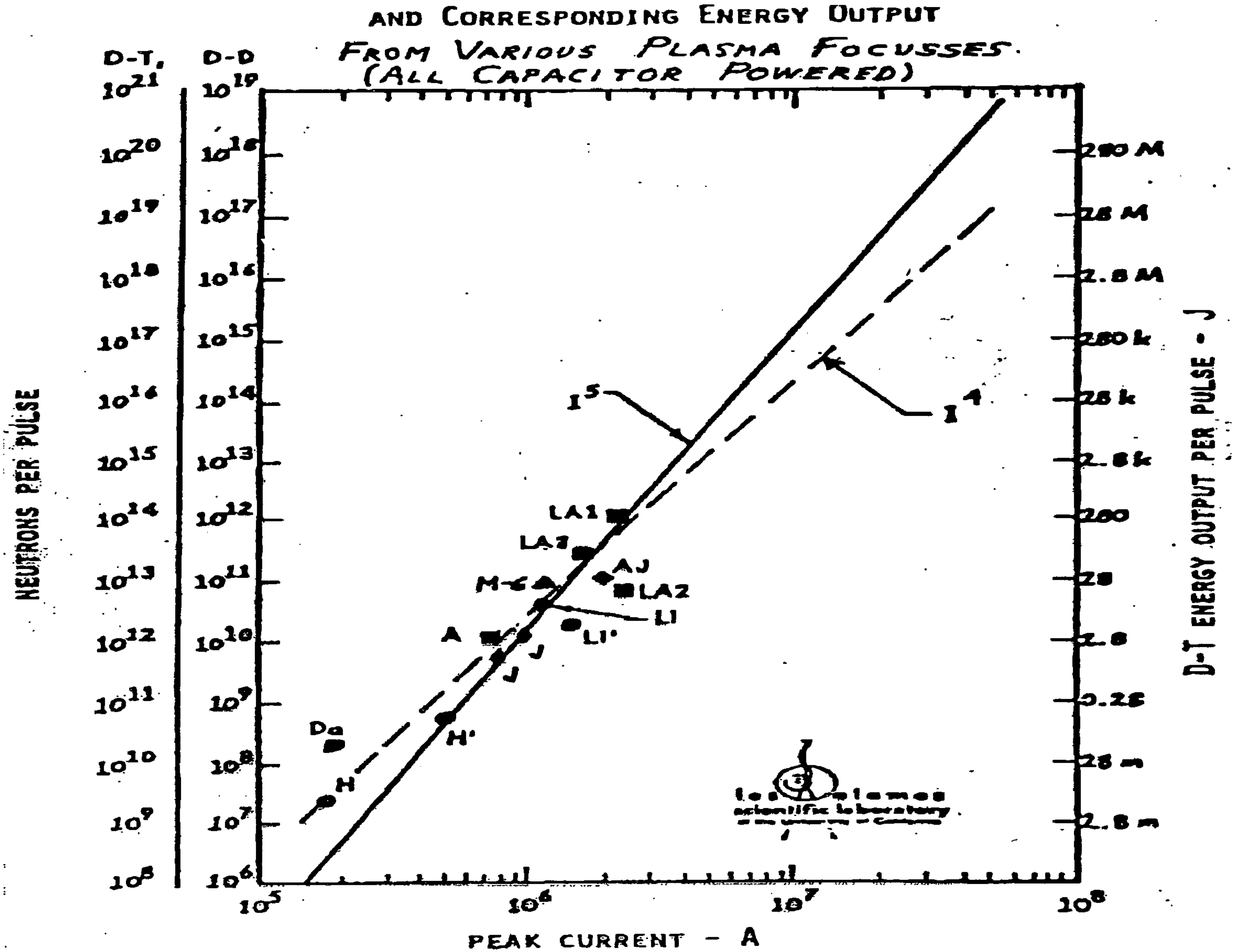
1. LAB SHOT, PEAK CURRENT: !.3 MA
2. 1X2 GENERATOR " : 1.6 MA
3. 1X4 GENERATOR " : 2.9 MA



Neutron Yields vs Current for Various DPF's



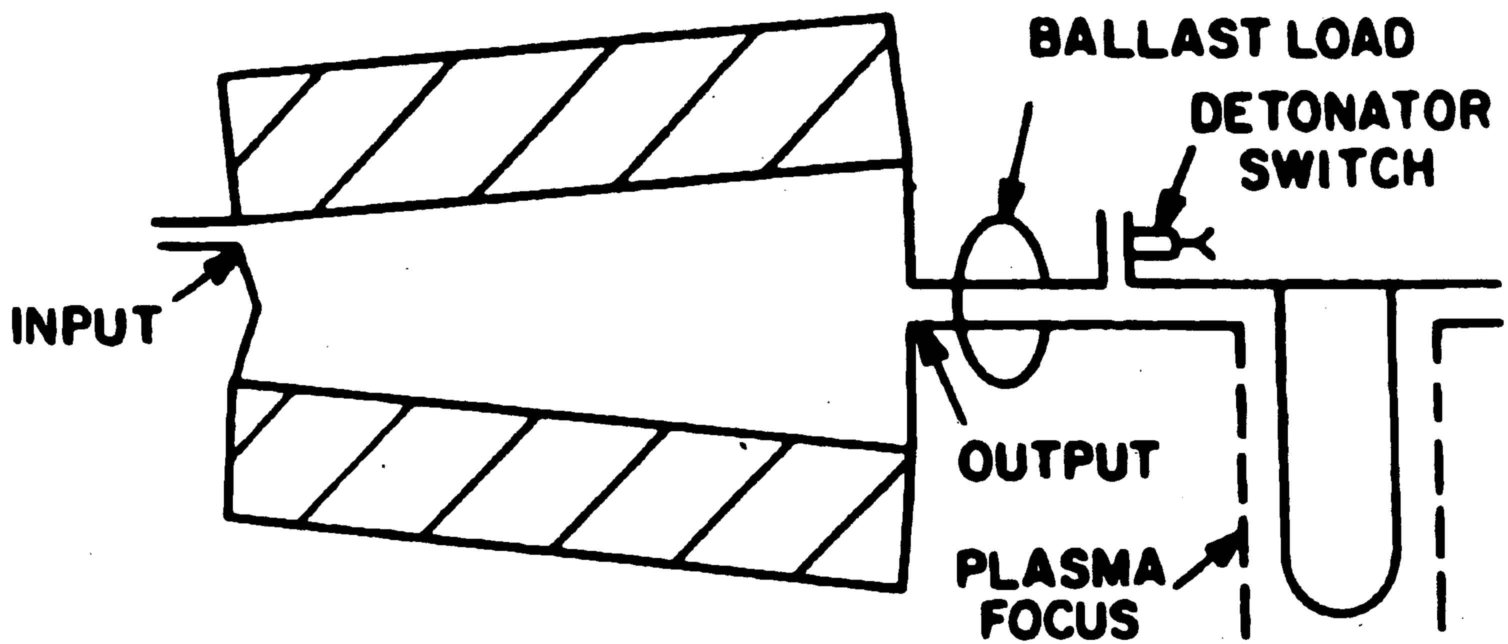
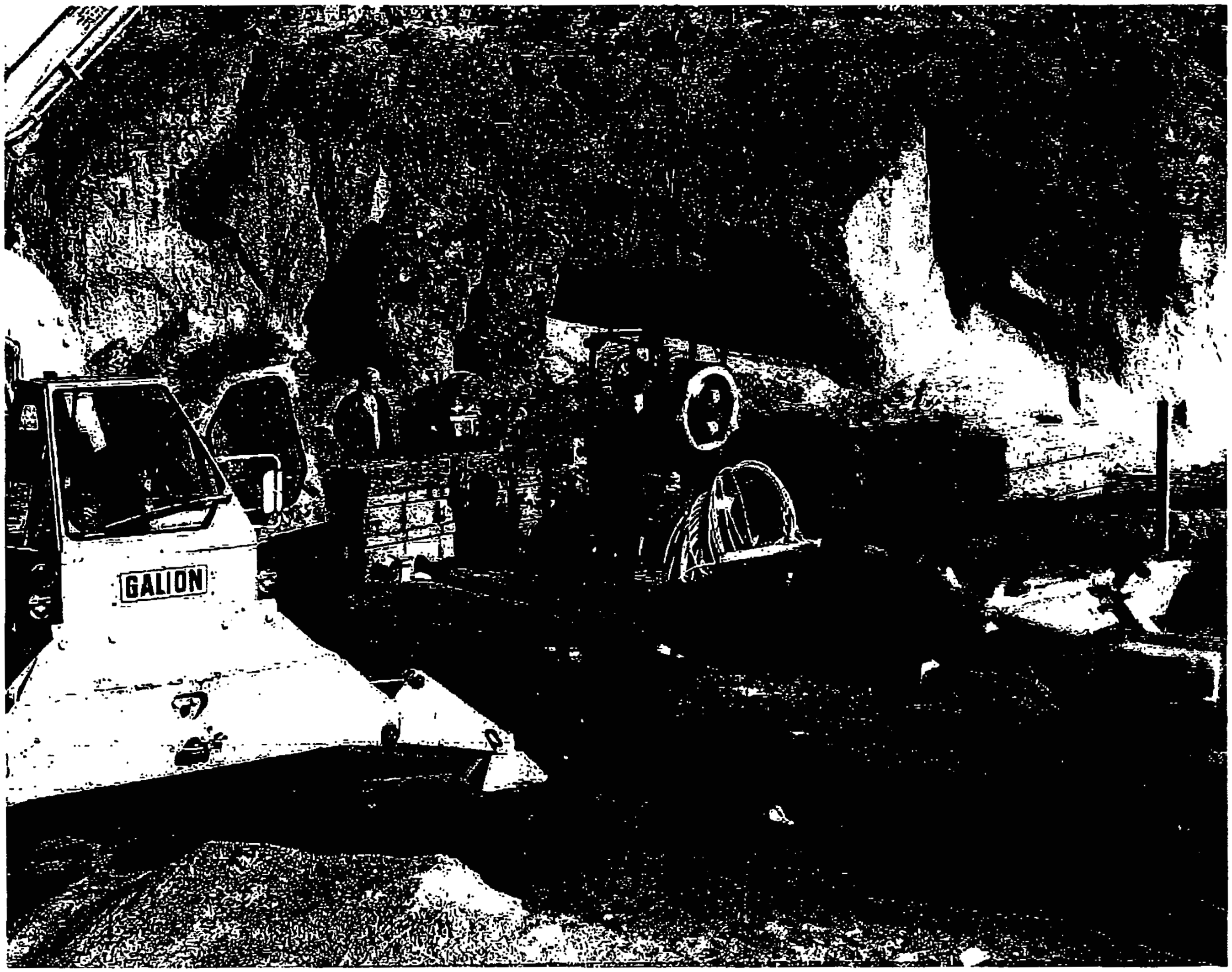
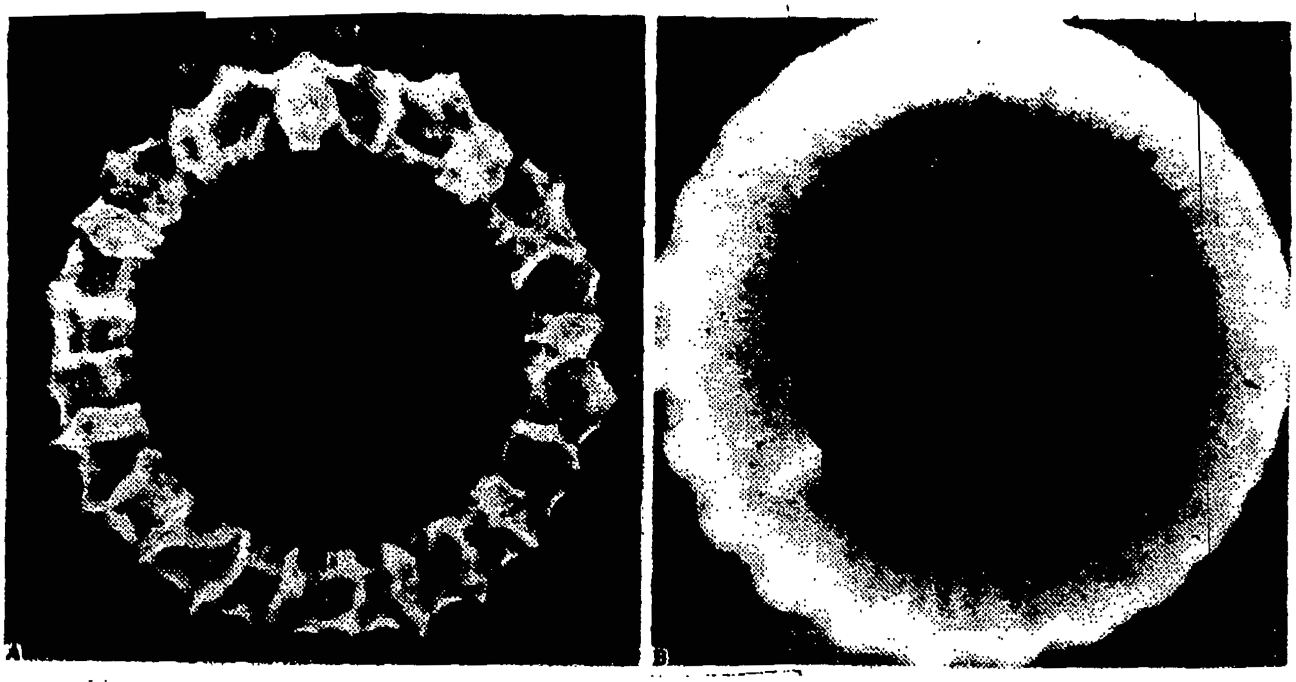


Fig.2. Schematic of a trapezoidal plate generator power supply to drive a plasma focus. The input of the generator is crowbarred with first plate motion. The detonator switch connects the plasma focus in parallel with the ballast load at 3-4 μs before generator burnout.

"Warmed-up" DPF About to be Connected to Pre-assembled Plate Generator System on Firing Pad





. End-on gated channel-plate camera photographs of the plasma sheath during rundown and initial collapse. 7A is 1.49 μs after the plasma focus has been switched into circuit. 7B is 2.79 μs in time and shows a late-time breech breakdown due to a vacuum chamber asymmetry

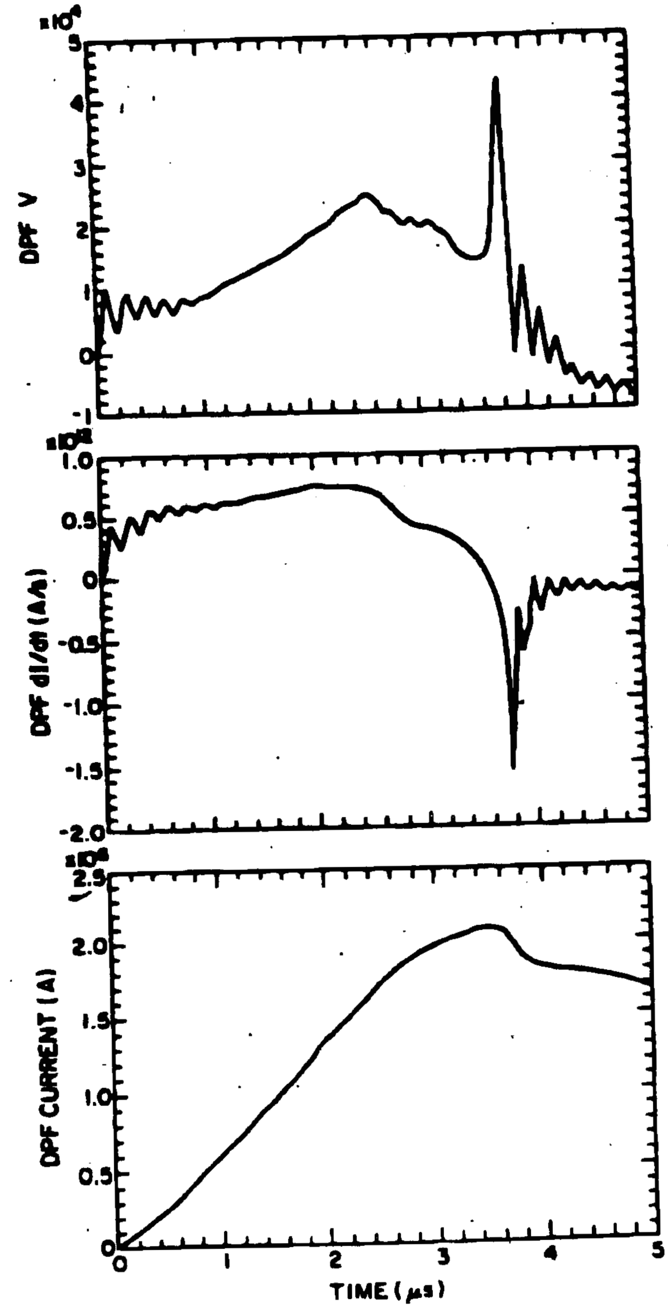


Fig.8. Characteristic (8A) voltage, (8B) current time-derivative, and (8C) current traces versus time for shot IV-2.

DPF: "Netnag" Calculations for Generator Powered Shot IV-2

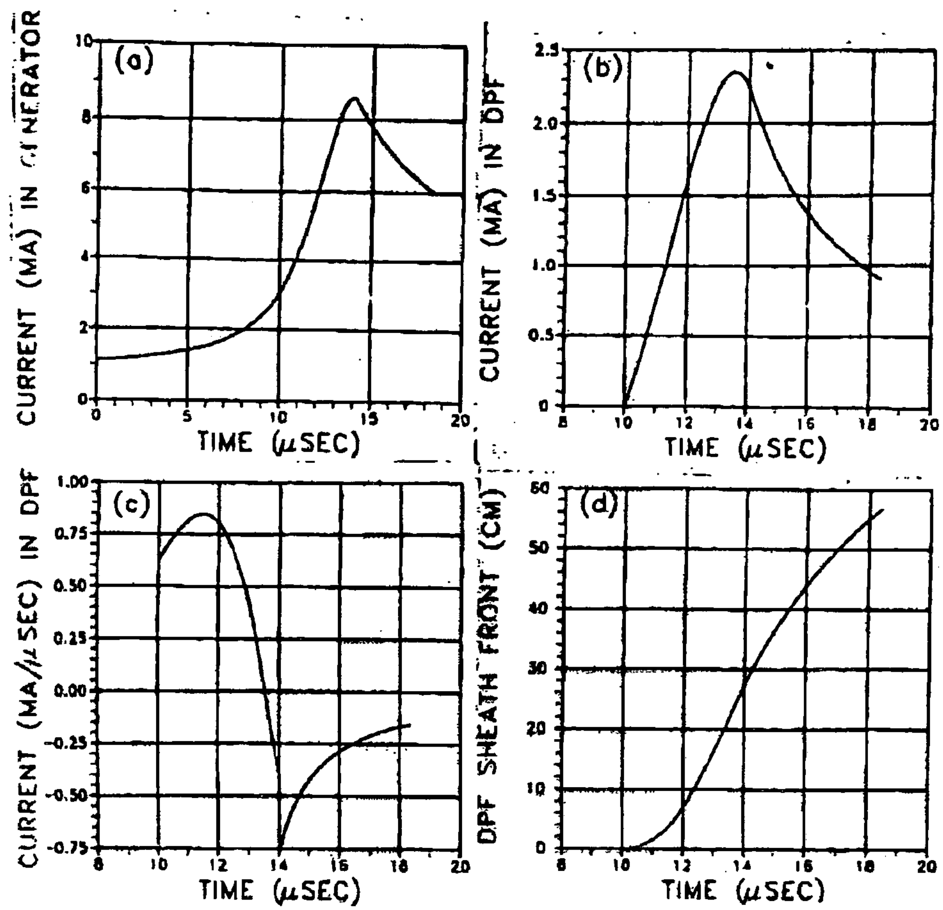
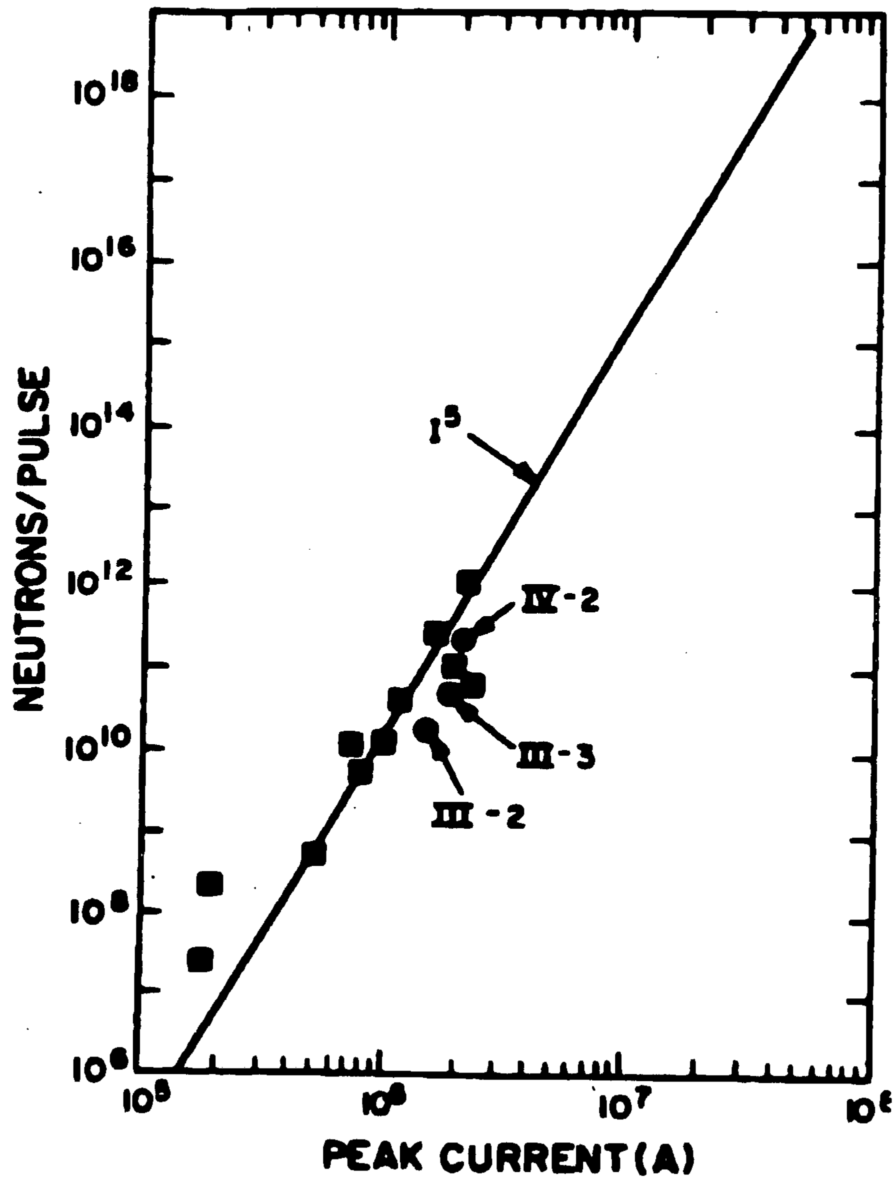


Figure 5. NETNAG calculations with parameters used in the Shot IV-2 of Fig. 1. (a) and (b) give current vs time in the FCG and DPF respectively. $\dot{I}$ in the DPF is given on (c) while the plasma sheath front is plotted on (d). The DPF was switched into the circuit (Fig. 4) at 10 μs.



Neutron yield versus peak current per pulse. The squared points are results obtained from various capacitor powered focusses, as before. Results from generator powered shots are shown as circles.

Circuit Schematic for Generator-Powered DPF with Fuse

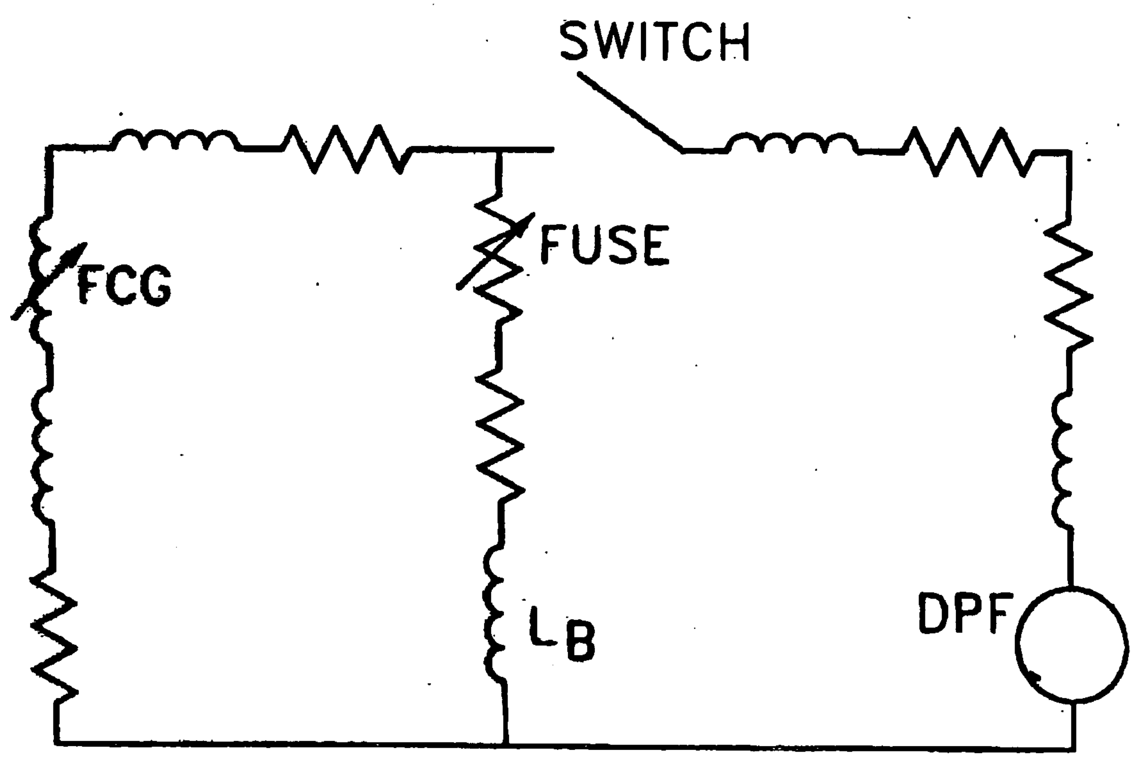
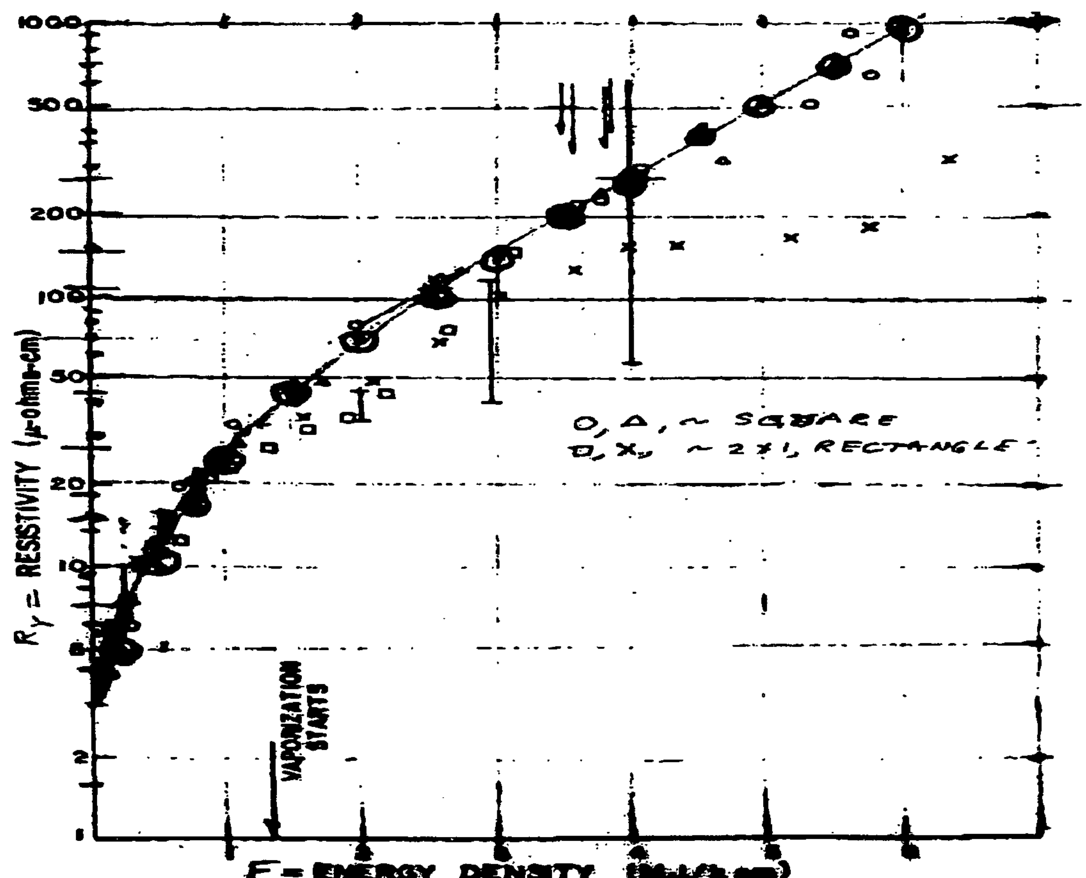


Figure 4. Diagram of circuit analysed by the NETNAG code. Various fuse, DPF and FCG models are available in the code.

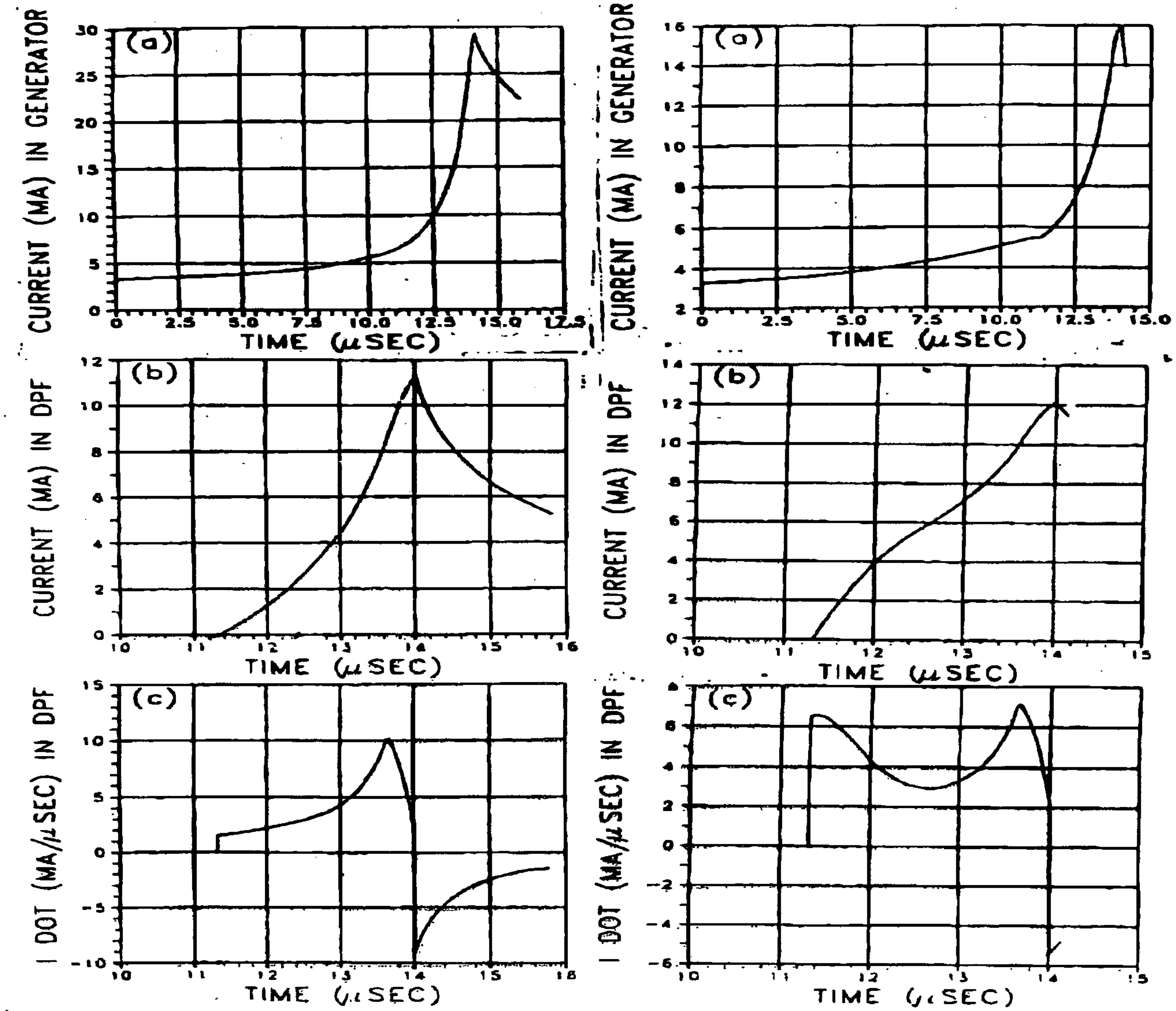
Copper Resistivity vs Absorbed Specific Energy (Burkhart and DiMarco)



J.N. DiMarco and L.C. Burkhardt J. Appl. Phys. 41, No. 9, 3894-3899, (1970)

-o-o-o- : $R_Y = 10^{-6}[1.7 + 20F + 2.8F^3]$

DPF: "Netnag" Calculations Comparing Currents and I dots with Fuse (Right) and Without Fuse (left)



The curves at the left give generator current, DPF current and DPF dI/dt calculated for a plate generator initially loaded to 3.3 MA. The DPF fill pressure was 50 torr and the switch time was 11.3 μs. The corresponding curves on the right were calculated with a fuse in the ballast load branch. Note the greatly reduced generator current and increased initial $\dot{I}$ values for this case.